DESCRIPTION OF THE INVENTION

1 What is the problem or issue (if any) that your invention is meant to solve?

The idle speed on a diesel engine is inherently unstable, so the idle speed has a tendency to wander or oscillate in situations where the load changes. This places a lot of burden on the idle speed governor control strategy, and in some cases the idle speed governor does not handle the additional demands well.

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2 How was the problem or issue handled (addressed/solved) ***before*** your invention? Attach sketches, drawings, photos, and/or reports where possible.

The problem of an unstable idle has been associated with the diesel engine since it was invented. A special "flyball" governor was added to a diesel engine to regulate idle speed, but that did not resolve problem of the inherent instability of the idle speed of a diesel engine. The idle speed of a diesel engine is unstable, even with the addition of a governor. The problem has not been handled or addressed in the past.

The idle speed of a diesel engine in the past has been unstable, because the control of engine speed at idle was based on controlling the fuel amount per stroke. The diesel engine can operate at many different engine speeds with the same approximate fuel quantity per stroke. Since the diesel engine can operate at many different engine speeds with the same fuel quantity per stroke, controlling the fuel quantity per stroke is not an effective means to control engine speed. The prior art of controlling fuel quantity per stroke was not an effective means to control engine speed, because fuel quantity per stroke does not define an associated engine speed. The issue of an unstable idle with a diesel engine has not been addressed with prior art.

A trend in the industry is to use separate computer modules for engine control and fuel control. The use of separate modules to control the engine and to control the fuel injectors has placed an added demand on the idle speed governor to make the idle speed control less stable. The communication and scheduling delays between the different modules creates a phase shift between the moment where engine speed is measured and when a change in fuel can take place. A phase shift in a feedback control system is commonly the limiting factor for the tuning of gains, because a phase shift makes the system unstable. When the inherent instability of the idle of a diesel engine is coupled with added phase shift due to separate computer modules, the idle control of a diesel engine can be seriously disturbed. The control of idle speed with a diesel engine will then be poor, causing poor response to a change in load if the gains are detuned for stability, or severe instability if the gains are tuned for good response. A fundamental change in the nature of the control of idle speed is required to avoid those pitfalls.

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3 How does your invention solve the problem or issue? Attach sketches, drawings, photos, and/or reports where possible.

The invention is an algorithm that changes the basic relationship between the idle governor to regulate engine speed and the fuel quantity injected to the engine. The algorithm changes the basic fuel control relationship at idle to provide for a stable idle, although the algorithm can be used throughout the engine operating range.

The idle speed governor controls the fuel flow on a mass flow rate, not a mass per stroke quantity. A conversion is made using engine speed to calculate fuel flow on a mass per stroke quantity. That provides for a stable system with negative feedback.

If the idle speed governor is locked to a particular fuel flow value, the engine is still a stable system. If the engine slows below the desired idle speed, the fuel flow rate remains fixed, but the fuel quantity per stroke increases. The engine will reach an equilibrium speed below the desired speed, but the engine will not stall due to an instability in the system. If the engine increases above the desired idle speed, the fuel flow rate remains fixed, but the fuel quantity per stroke decreases. The engine will reach an equilibrium speed above the desired speed, but the engine will not run away due to an instability in the system. The control of idle speed is stable when the idle speed governor controls to a fuel flow value.

With the current idle speed governor algorithms in software and mechanical mechanisms, the idle speed governor controls the fuel quantity on a per stroke basis. That is an unstable situation. If the idle speed governor is locked to a particular fuel quantity per stroke, the engine receives less fuel flow when the engine speed is too slow. That is an unstable situation. The engine receives less fuel flow on a rate basis when the engine needs the exactly the opposite. If the engine speed increases above the desired idle speed, the fuel per stroke remains fixed, but the fuel flow rate increases. That is also an unstable situation. If the engine is too fast, it is given more fuel on a rate basis when the engine needs exactly the opposite. The previous algorithms do not produce a stable idle speed as evidenced by the runaway or stall situations when the idle speed governor is locked.

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4 How does the invention tie in with an existing process or in a vehicle or in an engine? Attach sketches where applicable.

Every diesel engine has a requirement to idle. The algorithm provides an inherent mechanism to provide stability when idling a diesel engine.

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5 What are the main components of the invention or what are the main steps of the process that are new or different? Attach sketches, drawings, photos, and/or reports where possible.

The algorithm allows the diesel engine to have a stable idle by changing the basic method to control the fuel quantity. The prior idle speed control algorithms controlled fuel on a per stroke basis. With that arrangement, the aggregate fuel flow to the engine would increase as the engine speed would increase. If the engine speed decreased, the aggregate fuel flow to the engine would decrease. That is an inherently unstable system. More fuel flow is provided when less fuel flow is required. Less fuel flow is provided when more fuel flow is required. The idle speed governor is then burdened with stabilizing an inherently unstable system, and performance would suffer.

The non-ideal method to control idle speed was required, because the technology to practically control aggregate fuel flow directly based on engine speed did not exist. The fuel systems did not allow fuel flow to be directly commanded, so fuel per stroke was commanded. With the advent of full-authority electronic engine controls, the technology exists to control fuel flow based on engine speed. The burden of controlling fuel on a per stroke basis was lifted.

The algorithm controls aggregate fuel flow instead of fuel on a per stroke basis. Engine speed is used to convert the fuel flow command to a fuel per stroke command, but that is independent of the idle speed

control strategy. The inherently unstable characteristics of the engine idle are removed when the fuel flow is controlled instead of fuel per stroke.

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6 Describe the novel features, operations, and functions of the invention and identify the best way of implementing your invention. Describe all the components or steps involved.

The output of the idle speed control circuit is an aggregate fuel flow command in units of fuel quantity per time. The engine speed and number of cylinders are used to convert the fuel flow from units of fuel quantity per time into fuel quantity per stroke. The fuel quantity per stroke is an independent calculation based on the output of the idle speed control circuit, engine speed, and the number of cylinders. That way the engine does not receive more fuel flow per unit of time when the engine requires the exact opposite. The idle of the diesel engine is stable instead of unstable.

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